# Appendix I
# Framing Calculations/ Tables/Forms

## FRAMING CALCULATION APPROACHES/TABLES

When showing compliance with the building energy efficiency standard, the envelope assemblies U-value must meet the requirements of the standard. For wood and metal framed, light and heavy mass walls the tabulated default values or calculation methods presented in this section to determine the U-value of an assembly can be used in compliance.

***FRAMED WALL ASSEMBLY U-VALUES*** ***I-5-6***

If the wall assembly is very generic or there is no need to take advantage or evaluate specific components of a construction assembly, the default U-values in Table B-2 (see page I-4) can be used. Use of Table B-2 will significantly simplify compliance and save considerable time, however, the assumption used to develop these default tables are very conservative.

***METAL FRAMING FACTORS*** ***I-7***

This table includes values reference in Chapter 2 and Appendix G to be used to adjust U-value calculations using a parallel method when metal framing is calculated using the nonresidential ENV-3 form.

***PROPERTIES OF MASONRY WALLS*** ***I-8-9***

These tables list the U-value and Heat Capacity of basic types of masonry block construction. They also include the effects of insulation placed on block walls.

***EFFECTIVE R-VALUES FOR INTERIOR INSULATION LAYERSON STRUCTURAL MASS WALLS*** ***I-10-11***

These tables provide information for determining the effect of insulating a masonry wall.

***FRAMED FLOOR/CEILING ASSEMBLIES U-VALUES*** ***I-12***

This refers to Appendix H that includes diagrams and assembly U-value calculation for some basic ceiling and floor assemblies.

***U-VALUE CALCULATION PROCEDURE FOR CALCULATING METAL FRAMED ASSEMBLIES*** ***I-12***

This section refers to Appendix B of the *Nonresidential Manual*.

***COMPUTER MODELING OF FRAMED ASSEMBLIES*** ***I-12***

This Energy Commission has developed the EZ-FRAME program to automate ASHRAE procedures in order to help the building community in calculating the U-values of wood and metal framed assemblies with a higher degree of accuracy and speed. The output forms of this program can be used as part of a residential or nonresidential submittal.

***CONSTRUCTION ASSEMBLY FORMS*** ***I-13-20***

These are the directions for completing the ENV-3 forms (from the Nonresidential Manual) for metal frame, masonry, and wood frame assemblies. These forms can be used for residential compliance.

# Framed Wall Assembly U-values
# From Table B-2 Nonresidential Manual

| Framing Type and Spacing | Framing Cavity R-Value | Insulated Sheathing R-Value | Wood Wall U-Value | Metal Wall U-Value |
|---|---|---|---|---|
| 2x4 @ 16" O.C. | 11 | 0 | 0.098 | 0.202 |
| | (compressed) | 4 | 0.068 | 0.112 |
| | | 5 | 0.064 | 0.101 |
| | | 7 | 0.056 | 0.084 |
| | | 8.7 | 0.051 | 0.073 |
| | 13 | 0 | 0.088 | 0.195 |
| | | 4 | 0.063 | 0.109 |
| | | 5 | 0.059 | 0.099 |
| | | 7 | 0.052 | 0.082 |
| | | 8.7 | 0.048 | 0.072 |
| | 15 | 0 | 0.081 | 0.189 |
| | | 4 | 0.059 | 0.108 |
| | | 5 | 0.055 | 0.097 |
| | | 7 | 0.049 | 0.077 |
| | | 8.7 | 0.045 | 0.071 |
| 2x4 @ 24" O.C. | 11 | 0 | 0.094 | 0.173 |
| | | 4 | 0.066 | 0.102 |
| | | 5 | 0.062 | 0.093 |
| | | 7 | 0.055 | 0.078 |
| | | 8.7 | 0.050 | 0.069 |
| | 13 | 0 | 0.085 | 0.165 |
| | | 4 | 0.061 | 0.099 |
| | | 5 | 0.057 | 0.090 |
| | | 7 | 0.051 | 0.077 |
| | | 8.7 | 0.047 | 0.068 |
| | 15 | 0 | 0.077 | 0.158 |
| | | 4 | 0.056 | 0.097 |
| | | 5 | 0.053 | 0.088 |
| | | 7 | 0.047 | 0.071 |
| | | 8.7 | 0.044 | 0.067 |

| Framing Type and Spacing | Framing Cavity R-Value | Insulated Sheathing R-Value | Wood Wall U-Value | Metal Wall U-Value |
|---|---|---|---|---|
| 2x6 @ 16" O.C. | 19 | 0 | 0.065 | 0.120 |
| | (compressed) | 4 | 0.058 | 0.098 |
| | | 5 | 0.048 | 0.089 |
| | | 7 | 0.043 | 0.075 |
| | | 8.7 | 0.040 | 0.067 |
| | 21 | 0 | 0.059 | 0.157 |
| | | 4 | 0.046 | 0.096 |
| | | 5 | 0.044 | 0.088 |
| | | 7 | 0.041 | 0.075 |
| | | 8.7 | 0.037 | 0.066 |
| | 22 | 0 | 0.062 | 0.158 |
| | (compressed) | 4 | 0.048 | 0.097 |
| | | 5 | 0.045 | 0.088 |
| | | 7 | 0.041 | 0.075 |
| | | 8.7 | 0.038 | 0.067 |
| 2x6 @ 24" O.C. | 19 | 0 | 0.062 | 0.135 |
| | (compressed) | 4 | 0.048 | 0.088 |
| | | 5 | 0.045 | 0.081 |
| | | 7 | 0.042 | 0.070 |
| | | 8.7 | 0.039 | 0.062 |
| | 21 | 0 | 0.056 | 0.130 |
| | | 4 | 0.044 | 0.086 |
| | | 5 | 0.042 | 0.079 |
| | | 7 | 0.039 | 0.068 |
| | | 8.7 | 0.036 | 0.061 |
| | 22 | 0 | 0.058 | 0.132 |
| | (compressed) | 4 | 0.046 | 0.086 |
| | | 5 | 0.043 | 0.079 |
| | | 7 | 0.040 | 0.068 |
| | | 8.7 | 0.037 | 0.061 |

# Framed Wall Assembly U-values (cont'd)

| Framing Type and Spacing | Framing Cavity R-Value | Insulated Sheathing R-Value | Wood Wall U-Value | Metal Wall U-Value |
|---|---|---|---|---|
| 2x8 @ 16" O.C. | 19 | 0 | 0.059 | 0.145 |
| | | 4 | 0.047 | 0.092 |
| | | 5 | 0.044 | 0.084 |
| | | 7 | 0.041 | 0.072 |
| | | 8.7 | 0.038 | 0.064 |
| | 22 | 0 | 0.054 | 0.140 |
| | | 4 | 0.043 | 0.090 |
| | | 5 | 0.041 | 0.082 |
| | | 7 | 0.038 | 0.071 |
| | | 8.7 | 0.035 | 0.063 |
| | 25 | 0 | 0.050 | 0.136 |
| | | 4 | 0.040 | 0.088 |
| | | 5 | 0.038 | 0.081 |
| | | 7 | 0.035 | 0.070 |
| | | 8.7 | 0.033 | 0.062 |
| | 30 (compressed) | 0 | 0.048 | 0.135 |
| | | 4 | 0.039 | 0.088 |
| | | 5 | 0.037 | 0.081 |
| | | 7 | 0.035 | 0.070 |
| | | 8.7 | 0.032 | 0.062 |
| 2x8 @ 24" O.C. | 19 | 0 | 0.056 | 0.122 |
| | | 4 | 0.045 | 0.082 |
| | | 5 | 0.043 | 0.076 |
| | | 7 | 0.040 | 0.066 |
| | | 8.7 | 0.037 | 0.059 |
| | 22 | 0 | 0.051 | 0.117 |
| | | 4 | 0.041 | 0.080 |
| | | 5 | 0.040 | 0.074 |
| | | 7 | 0.036 | 0.064 |
| | | 8.7 | 0.034 | 0.058 |
| | 25 | 0 | 0.047 | 0.113 |
| | | 4 | 0.038 | 0.078 |
| | | 5 | 0.037 | 0.072 |
| | | 7 | 0.034 | 0.063 |
| | | 8.7 | 0.032 | 0.057 |
| | 30 (compressed) | 0 | 0.046 | 0.112 |
| | | 4 | 0.037 | 0.077 |
| | | 5 | 0.036 | 0.072 |
| | | 7 | 0.034 | 0.063 |
| | | 8.7 | 0.031 | 0.057 |

| Framing Type and Spacing | Framing Cavity R-Value | Insulated Sheathing R-Value | Wood Wall U-Value | Metal Wall U-Value |
|---|---|---|---|---|
| 2x10 @ 16" O.C. | 30 | 0 | 0.041 | 0.120 |
| | | 4 | 0.035 | 0.081 |
| | | 5 | 0.033 | 0.075 |
| | | 7 | 0.031 | 0.065 |
| | | 8.7 | 0.029 | 0.059 |
| | 38 (compressed) | 0 | 0.040 | 0.119 |
| | | 4 | 0.033 | 0.080 |
| | | 5 | 0.032 | 0.074 |
| | | 7 | 0.030 | 0.065 |
| | | 8.7 | 0.028 | 0.058 |
| 2x10 @ 24" O.C. | 30 (compressed) | 0 | 0.039 | 0.099 |
| | | 4 | 0.033 | 0.071 |
| | | 5 | 0.032 | 0.066 |
| | | 7 | 0.030 | 0.058 |
| | | 8.7 | 0.028 | 0.053 |
| | 38 | 0 | 0.038 | 0.097 |
| | | 4 | 0.032 | 0.070 |
| | | 5 | 0.031 | 0.066 |
| | | 7 | 0.029 | 0.058 |
| | | 8.7 | 0.027 | 0.053 |

## Metal Framing Factor

| METAL FRAMING FACTORS | | | |
|---|---|---|---|
| Stud Spacing | Stud Depth | Insulation R-Value | Framing Factor |
| 16" o.c. | 4" | R-7 | 0.522 |
| | | R-11 | 0.403 |
| | | R-13 | 0.362 |
| | | R-15 | 0.328 |
| | 6" | R-19 | 0.325 |
| | | R-21 | 0.300 |
| | | R-22 | 0.287 |
| | | R-25 | 0.263 |
| 24" o.c. | 4" | R-7 | 0.577 |
| | | R-11 | 0.458 |
| | | R-13 | 0.415 |
| | | R-15 | 0.379 |
| | 6" | R-19 | 0.375 |
| | | R-21 | 0.348 |
| | | R-22 | 0.335 |
| | | R-25 | 0.308 |
| R-value calculation for Exterior Wall Assemblies with Metal Studs, July, 19, 1990, Staff Draft Docket 90-CON-1. | | | |
| *Correction to metal framing factors applies to the entire assembly including: interior air films, interior surfaces, cavity/insulation, exterior surfaces, and exterior air films. | | | |

# Properties of Hollow Unit Masonry Walls

| Type | | | Core Treatment | | |
|---|---|---|---|---|---|
| | | | Solid Grout | Partly Grouted with Ungrouted Cells | |
| | | | | Empty | Insulated |
| 12" | LW CMU | U | 0.51 | 0.43 | 0.30 |
| | | Rw | 2.0 | 2.3 | 3.3 |
| | | HC | 23 | 14.8 | 14.8 |
| | MW CMU | U | 0.54 | 0.46 | 0.33 |
| | | Rw | 1.9 | 2.2 | 3.0 |
| | | HC | 23.9 | 15.6 | 15.6 |
| | NW CMU | U | 0.57 | 0.49 | 0.36 |
| | | Rw | 1.8 | 2.0 | 2.8 |
| | | HC | 24.8 | 16.5 | 16.5 |
| 10" | LW CMU | U | 0.55 | 0.46 | 0.34 |
| | | Rw | 1.8 | 2.2 | 2.9 |
| | | HC | 18.9 | 12.6 | 12.6 |
| | MW CMU | U | 0.59 | 0.49 | 0.37 |
| | | Rw | 1.7 | 2.1 | 2.7 |
| | | HC | 19.7 | 13.4 | 13.4 |
| | NW CMU | U | 0.62 | 0.52 | 0.41 |
| | | Rw | 1.6 | 1.9 | 2.4 |
| | | HC | 20.5 | 14.2 | 14.2 |
| 8" | LW CMU | U | 0.62 | 0.50 | 0.37 |
| | | Rw | 1.6 | 2.0 | 2.7 |
| | | HC | 15.1 | 9.9 | 9.9 |
| | MW CMU | U | 0.65 | 0.53 | 0.41 |
| | | Rw | 1.5 | 1.9 | 2.4 |
| | | HC | 15.7 | 10.5 | 10.5 |
| | NW CMU | U | 0.69 | 0.56 | 0.44 |
| | | Rw | 1.4 | 1.8 | 2.3 |
| | | HC | 16.3 | 11.1 | 11.1 |
| | Clay Unit | U | 0.57 | 0.47 | 0.39 |
| | | Rw | 1.8 | 2.1 | 2.6 |
| | | HC | 15.1 | 11.4 | 11.4 |
| 6" | LW CMU | U | 0.68 | 0.54 | 0.44 |
| | | Rw | 1.5 | 1.9 | 2.3 |
| | | HC | 10.9 | 7.9 | 7.9 |
| | MW CMU | U | 0.72 | 0.58 | 0.48 |
| | | Rw | 1.4 | 1.7 | 2.1 |
| | | HC | 11.4 | 8.4 | 8.4 |
| | NW CMU | U | 0.76 | 0.61 | 0.52 |
| | | Rw | 1.3 | 1.6 | 1.9 |
| | | HC | 11.9 | 8.9 | 8.9 |
| | Clay Unit | U | 0.65 | 0.52 | 0.45 |
| | | Rw | 1.5 | 1.9 | 2.2 |
| | | HC | 11.1 | 8.6 | 8.6 |

Notes:
LW CMU is a Light Weight Concrete Masonry Unit per ASTM C 90, Calculated at 105 PCF density
MW CMU is a Medium Weight Concrete Masonry Unit per ASTM C 90, Calculated at 115 PCF density
NW CMU is a Normal Weight Concrete Masonry Unit per ASTM C 90, Calculated at 125 PCF density
Clay Unit is a Hollow Clay Unit per ASTM C 652, Calculated at 130 PCF density
Values include air films on inner and outer surfaces.
Calculations based on Energy Calculations and Data, CMACN, 1986
Grouted Cells at 32" X 48" in Partly Grouted Walls
Source: Berkeley Solar Group; Concrete Masonry Association of California and Nevada

# Properties of Solid Unit Masonry and Solid Concrete Walls

| Type | | Layer Thickness, inches | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| LW CMU | U | na | 0.71 | 0.64 | Na | na | na | na | na | na | na |
| | Rw | na | 1.4 | 1.6 | Na | na | na | na | na | na | na |
| | HC | na | 7.00 | 8.75 | Na | na | na | na | na | na | na |
| MW CMU | U | na | 0.76 | 0.70 | Na | na | na | na | na | na | na |
| | Rw | na | 1.3 | 1.4 | Na | na | na | na | na | na | na |
| | HC | na | 7.67 | 9.58 | Na | na | na | na | na | na | na |
| NW CMU | U | 0.89 | 0.82 | 0.76 | Na | na | na | na | na | na | na |
| | Rw | 1.1 | 1.2 | 1.3 | Na | na | na | na | na | na | na |
| | HC | 6.25 | 8.33 | 10.42 | Na | na | na | na | na | na | na |
| Clay Brick | U | 0.80 | 0.72 | 0.66 | Na | na | na | na | na | na | na |
| | Rw | 1.3 | 1.4 | 1.5 | Na | na | na | na | na | na | na |
| | HC | 6.30 | 8.40 | 10.43 | Na | na | na | na | na | na | na |
| Concrete | U | 0.96 | 0.91 | 0.86 | 0.82 | 0.78 | 0.74 | 0.71 | 0.68 | 0.65 | 0.63 |
| | Rw | 1.0 | 1.1 | 1.2 | 1.2 | 1.3 | 1.4 | 1.4 | 1.5 | 1.5 | 1.6 |
| | HC | 7.20 | 9.60 | 12.00 | 14.40 | 16.80 | 19.20 | 21.60 | 24.00 | 26.40 | 28.80 |

Notes:
LW CMU is a Light Weight Concrete Masonry Unit per ASTM C 90 or 55, Calculated at 105 PCF density
MW CMU is a Medium Weight Concrete Masonry Unit per ASTM C 90 or 55, Calculated at 115 PCF density
NW CMU is a Normal Weight Concrete Masonry Unit per ASTM C 90 or 55, Calculated at 125 PCF density
Clay Brick is a Clay Unit per ASTM C 62, Calculated at 130 PCF density
Concrete is stuctural poured or precast concrete, Calculated at 144 PCF density
Calculations based on Energy Calculations and Data, CMACN, 1986
Values include air films on inner and outer surfaces.
Source: Berkeley Solar Group; Concrete Masonry Association of California and Nevada

# Effective R-values for Interior Insulation Layers on Structural Mass Walls

| Type Actual Thick | Frame | Furring space R-value without framing effects | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 |
| Any | None | 0.5 | 1.5 | 2.5 | 3.5 | 4.5 | 5.5 | 6.5 | 7.5 | 8.5 | 9.5 | 10 | 11.5 | 12.5 | 13.5 | 14.5 | 15.5 | 16.5 | 17.5 | 18.5 | 19.5 | 20.5 | 21.5 |
| 0.5" | Wood | 1.3 | 1.3 | 1.9 | 2.4 | 2.7 | na | na | na | na | na | na | na | na | na | na | na | na | na | na | na | na | na |
| | Metal | 0.9 | 0.9 | 1.1 | 1.1 | 1.2 | na | na | na | na | na | na | na | na | na | na | na | na | na | na | na | na | na |
| 0.75" | Wood | 1.4 | 1.4 | 2.1 | 2.7 | 3.1 | 3.5 | 3.8 | na | na | na | na | na | na | na | na | na | na | na | na | na | na | na |
| | Metal | 1.0 | 1.0 | 1.3 | 1.4 | 1.5 | 1.5 | 1.6 | na | na | na | na | na | na | na | na | na | na | na | na | na | na | na |
| 1.0" | Wood | 1.3 | 1.5 | 2.2 | 2.9 | 3.4 | 3.9 | 4.3 | 4.6 | 4.9 | na | na | na | na | na | na | na | na | na | na | na | na | na |
| | Metal | 1.0 | 1.1 | 1.4 | 1.6 | 1.7 | 1.8 | 1.8 | 1.9 | 1.9 | na | na | na | na | na | na | na | na | na | na | na | na | na |
| 1.5" | Wood | 1.3 | 1.5 | 2.4 | 3.1 | 3.8 | 4.4 | 4.9 | 5.4 | 5.8 | 6.2 | 6.5 | 6.8 | 7.1 | na | na | na | na | na | na | na | na | na |
| | Metal | 1.1 | 1.2 | 1.6 | 1.9 | 2.1 | 2.2 | 2.3 | 2.4 | 2.5 | 2.5 | 2.6 | 2.6 | 2.7 | na | na | na | na | na | na | na | na | na |
| 2" | Wood | 1.4 | 1.5 | 2.5 | 3.3 | 4.0 | 4.7 | 5.3 | 5.9 | 6.4 | 6.9 | 7.3 | 7.7 | 8.1 | 8.4 | 8.7 | 9.0 | 9.3 | na | na | na | na | na |
| | Metal | 1.1 | 1.2 | 1.7 | 2.1 | 2.3 | 2.5 | 2.7 | 2.8 | 2.9 | 3.0 | 3.1 | 3.2 | 3.2 | 3.3 | 3.3 | 3.4 | 3.4 | na | na | na | na | na |
| 2.5" | Wood | 1.4 | 1.5 | 2.5 | 3.4 | 4.2 | 4.9 | 5.6 | 6.3 | 6.8 | 7.4 | 7.9 | 8.4 | 8.8 | 9.2 | 9.6 | 10.0 | 10.3 | 10.6 | 10.9 | 11.2 | 11.5 | na |
| | Metal | 1.2 | 1.3 | 1.8 | 2.3 | 2.6 | 2.8 | 3.0 | 3.2 | 3.3 | 3.5 | 3.6 | 3.6 | 3.7 | 3.8 | 3.9 | 3.9 | 4.0 | 4.0 | 4.1 | 4.1 | 4.1 | na |
| 3" | Wood | 1.4 | 1.5 | 2.5 | 3.5 | 4.3 | 5.1 | 5.8 | 6.5 | 7.2 | 7.8 | 8.3 | 8.9 | 9.4 | 9.9 | 10.3 | 10.7 | 11.1 | 11.5 | 11.9 | 12.2 | 12.5 | 12.9 |
| | Metal | 1.2 | 1.3 | 1.9 | 2.4 | 2.8 | 3.1 | 3.3 | 3.5 | 3.7 | 3.8 | 4.0 | 4.1 | 4.2 | 4.3 | 4.4 | 4.4 | 4.5 | 4.6 | 4.6 | 4.7 | 4.7 | 4.8 |
| 3.5" | Wood | 1.4 | 1.5 | 2.6 | 3.5 | 4.4 | 5.2 | 6.0 | 6.7 | 7.4 | 8.1 | 8.7 | 9.3 | 9.8 | 10.4 | 10.9 | 11.3 | 11.8 | 12.2 | 12.6 | 13.0 | 13.4 | 13.8 |
| | Metal | 1.2 | 1.3 | 2.0 | 2.5 | 2.9 | 3.2 | 3.5 | 3.8 | 4.0 | 4.2 | 4.3 | 4.5 | 4.6 | 4.7 | 4.8 | 4.9 | 5.0 | 5.1 | 5.1 | 5.2 | 5.2 | 5.3 |
| 4" | Wood | 1.4 | 1.6 | 2.6 | 3.6 | 4.5 | 5.3 | 6.1 | 6.9 | 7.6 | 8.3 | 9.0 | 9.6 | 10.2 | 10.8 | 11.3 | 11.9 | 12.4 | 12.8 | 13.3 | 13.7 | 14.2 | 14.6 |
| | Metal | 1.2 | 1.3 | 2.0 | 2.6 | 3.0 | 3.4 | 3.7 | 4.0 | 4.2 | 4.5 | 4.6 | 4.8 | 5.0 | 5.1 | 5.2 | 5.3 | 5.4 | 5.5 | 5.6 | 5.7 | 5.8 | 5.8 |
| 4.5" | Wood | 1.4 | 1.6 | 2.6 | 3.6 | 4.5 | 5.4 | 6.2 | 7.1 | 7.8 | 8.5 | 9.2 | 9.9 | 10.5 | 11.2 | 11.7 | 12.3 | 12.8 | 13.3 | 13.8 | 14.3 | 14.8 | 15.2 |
| | Metal | 1.2 | 1.3 | 2.1 | 2.6 | 3.1 | 3.5 | 3.9 | 4.2 | 4.5 | 4.7 | 4.9 | 5.1 | 5.3 | 5.4 | 5.6 | 5.7 | 5.8 | 5.9 | 6.0 | 6.1 | 6.2 | 6.3 |
| 5" | Wood | 1.4 | 1.6 | 2.6 | 3.6 | 4.6 | 5.5 | 6.3 | 7.2 | 8 | 8.7 | 9.4 | 10.1 | 10.8 | 11.5 | 12.1 | 12.7 | 13.2 | 13.8 | 14.3 | 14.8 | 15.3 | 15.8 |
| | Metal | 1.2 | 1.4 | 2.1 | 2.7 | 3.2 | 3.7 | 4.1 | 4.4 | 4.7 | 5.0 | 5.2 | 5.4 | 5.6 | 5.8 | 5.9 | 6.1 | 6.2 | 6.3 | 6.5 | 6.6 | 6.7 | 6.8 |
| 5.5" | Wood | 1.4 | 1.6 | 2.6 | 3.6 | 4.6 | 5.5 | 6.4 | 7.3 | 8.1 | 8.9 | 9.6 | 10.3 | 11.0 | 11.7 | 12.4 | 13.0 | 13.6 | 14.2 | 14.7 | 15.3 | 15.8 | 16.3 |
| | Metal | 1.3 | 1.4 | 2.1 | 2.8 | 3.3 | 3.8 | 4.2 | 4.6 | 4.9 | 5.2 | 5.4 | 5.7 | 5.9 | 6.1 | 6.3 | 6.4 | 6.6 | 6.7 | 6.8 | 7.0 | 7.1 | 7.2 |

All furring thickness values given are actual dimensions

All values include .5" gypbd. on the inner surface, interior surface resistances not included

24" OC Furring 24 Gage, Z-type Metal Furring Douglas-Fir Larch Wood Furring, density = 34.9 lb/cu.ft.

Insulation assumed to fill the furring space

[Source: Berkeley Solar Group; Concrete Masonry Association of California and Nevada]

## Framed Floor/Ceiling and Wall Assemblies

Samples of framed floor, ceiling and wall assemblies with U-value calculations are located in Appendix H.

## U-Value Calculation Procedure for Calculating Metal Framed Assemblies

For sample calculations of metal framed assemblies not found in Appendix H and all of the ASHRAE methods, including the parallel path, zonal method, and isothermal plane method, see Appendix B of the Nonresidential Manual. That section can be used to calculate the U-value of more complex assemblies or develop a better understanding of heat transfer through different types of construction assemblies.

## Computer Modeling of Framed Assemblies

*EZFrame* can be purchased by ordering the following:

| | |
|---|---|
| Publication No.: | P400-94-002R |
| Cost: | $14.00 |
| Address: | California Energy Commission<br>Publications, MS-13<br>P.O. Box 944295<br>Sacramento, CA 94244-2950 |

# Construction Assembly Forms

Note: All of the following forms can be used for residential compliance.

## ENV-3: Proposed Metal Framed Assembly

For most metal framed assemblies, the U-value will be found in Table B-2 in Appendix B (see Section 3.1.2E for a discussion of the use of this table). When there is no appropriate U-value in Table B-2, then this version of ENV-3 should be used to calculate the assembly U-value.

[Note that this form is not used to describe metal furring systems for insulating masonry or concrete walls; these are described in ENV-3 Masonry Assemblies.]

1. **PROJECT NAME** is the title of the project, as shown on the plans and known to the building department.

2. **DATE** is the date of preparation of the compliance submittal package. It should be on or after the date of the plans, and on or before the date of the building permit application.

### *A. Component Description*

1. **SKETCH OF ASSEMBLY** - provide a simple cross-section sketch showing the arrangement of components in the assembly. The position of framing members and layers should be apparent. Number the layers in sequence from outside to inside as they will be described below (framing members are not numbered, only the cavity layers are considered here). Note that the outside of the assembly, facing unconditioned space, is at the left.
2. **ASSEMBLY NAME** - list the name or designator for this assembly as it is referred to on the plans and on the other compliance forms in the submittal, e.g. WALL-1, ROOF-2, or some other naming convention appropriate to the construction document organization.
3. **ASSEMBLY TYPE** - check the appropriate box.
4. **FRAMING MATERIAL** - must be metal for this form (other versions of ENV-3 are for other framing materials).
5. **FRAMING SIZE** - enter the nominal dimensions of the framing members, e.g. 3 1/2", 5 1/2", or other appropriate description.
6. **INSULATION R-VALUE** - enter the R-value of the insulation material in the assembly. If there is more than one insulation material, list each separately.

### *B. Construction Components*

In this part of the form, the R-value of the cavity (the area of the wall that does not contain framing members) is calculated.

1. **DESCRIPTION** - list each layer of the assembly in sequence, from outside to inside, as numbered in the sketch above.

2. **CAVITY R-VALUE ($R_c$) -** enter the R-value of each layer. This value is taken from manufacturers' literature or from the *ASHRAE Handbook of Fundamentals Volume, 1993,* Chapter 22, Table 4, *Typical Thermal Properties of Common Building and Insulating Materials.* The R-values for the INSIDE and OUTSIDE SURFACE AIR FILMS are taken from Table 3-1, Standard Air Film R-values.

3. **METAL FRAMING FACTOR (MFF)** - enter the appropriate value for the assembly from Table 3-5 (Appendix B, Table B-4), or the table on the form.

4. **Rc X MFF** - multiply the SUBTOTAL R-value ($R_c$) for the cavity by the METAL FRAMING FACTOR and enter the result.

5. **INSULATING SHEATHING -** if there is a layer of insulating sheathing (other than the cavity insulation between the framing members), enter its R-value. Only values from *ASHRAE Handbook of Fundamentals Volume, 1993,* Table 3a, Chapter 23, may be used.

6. **TOTAL R-VALUE ($R_t$)** - add the previous two numbers and enter the result here.

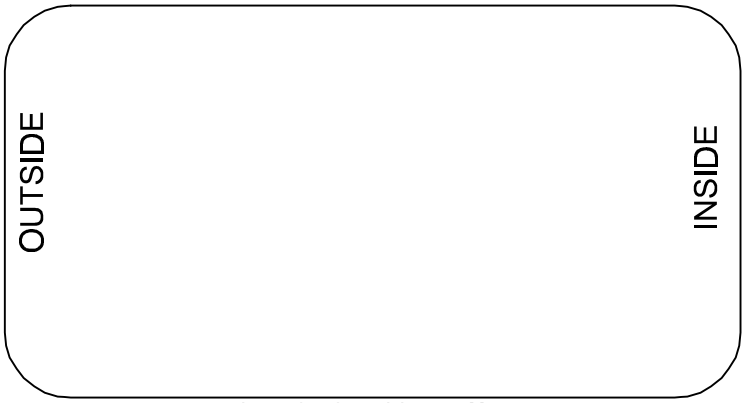
7. **ASSEMBLY U-VALUE** - divide 1 by the TOTAL R-VALUE ($R_t$) to obtain the ASSEMBLY U-VALUE.

**COMMENTS** may be added to further explain the assembly or its U-value calculation. This would be especially helpful for unusual assemblies, and could help to expedite plan checking for energy compliance.

# PROPOSED METAL FRAMED ASSEMBLY ENV-3

| PROJECT NAME | DATE |
|---|---|
| | |

## COMPONENT DESCRIPTION




SKETCH OF ASSEMBLY

**ASSEMBLY NAME**

**ASSEMBLY TYPE** ☐ Floor ☐ Wall ☐ Ceiling/Roof

**FRAMING MATERIAL**

**FRAMING SIZE**

**FRAMING SPACING** 16" o. c.☐ 24" o. c.☐

**INSULATION R-VALUE**

## CONSTRUCTION COMPONENTS

| | DESCRIPTION | CAVITY R-VALUE (Rc) |
|---|---|---|
| | **OUTSIDE SURFACE AIR FILM** | |
| 1 | | |
| 2 | | |
| 3 | | |
| 4 | | |
| 5 | | |
| 6 | | |
| 7 | | |
| | **INSIDE SURFACE AIR FILM** | |

| | | |
|---|---|---|
| **SUBTOTAL** | | Rt |
| **METAL FRAMING FACTOR** | | MFF |
| **Rt × MFF** | | R-VALUE |
| **INSULATING SHEATHING** | | R-VALUE |
| **TOTAL R-VALUE** | | Rt |
| **1/Rt** | | ASSEMBLY U-VALUE |

**METAL FRAMING FACTOR**

| Stud Spacing | Stud Depth | Insulation R-Value | Non-Mass Wall |
|---|---|---|---|
| 16 o. c. | 4" | R-7 | 0.522 |
| | | R-11 | 0.403 |
| | | R-13 | 0.362 |
| | | R-15 | 0.328 |
| | 6" | R-19 | 0.325 |
| | | R-21 | 0.300 |
| | | R-22 | 0.287 |
| | | R-25 | 0.263 |
| 24 o. c. | 4" | R-7 | 0.577 |
| | | R-11 | 0.458 |
| | | R-13 | 0.415 |
| | | R-15 | 0.379 |
| | 6" | R-19 | 0.375 |
| | | R-21 | 0.348 |
| | | R-22 | 0.335 |
| | | R-25 | 0.308 |

## COMMENTS

# ENV-3: Proposed Masonry Wall Assembly

This version of ENV-3 should be used for masonry wall assemblies (including concrete block, brick and solid concrete). It is used in conjunction with Tables B-5 and B-6 in Appendix B, which give U-values and heat capacities for most common assemblies. It should also be used to account for the insulating qualities of insulating sheathing and/or furred sheathing layers attached to the masonry. Refer to Section 3.1.2F for further description of these calculations.

1. **PROJECT NAME** is the title of the project, as shown on the plans, on the ENV-1, and as known to the building department.

2. **DATE** is the date of preparation of the compliance submittal package. It should be on or after the date of the plans, and on or before the date of the building permit application.

## *A. Component Description*

1. **SKETCH OF ASSEMBLY** - provide a simple cross-section sketch showing the arrangement of components in the assembly. The position of any furring members and sheathing layers should be apparent. Note that the outside of the assembly, facing unconditioned space, is at the left.

2. **WALL ASSEMBLY NAME** - list the name or designator for this wall assembly as it is referred to on the plans and on the other compliance forms in the submittal, e.g. WALL-1, or some other naming convention appropriate to the construction document organization.

3. **DESCRIPTION OF ASSEMBLY** - provide a brief description of the materials used in the assembly to augment the sketch.

## *B. Wall R-value and Heat Capacity*

This section is used to extract values of wall R-value and heat capacity from Tables B-5 or B-6 in Appendix B.

1. **WALL UNIT THICKNESS** - enter the nominal thickness, in inches, of the masonry wall.

2. **MATERIAL TYPE** - enter the material type. For concrete block, this can be “light weight”, “medium weight”, or “normal weight” as per ASTM designations.

3. **CORE TREATMENT** - this is only applicable to hollow core masonry units; the choices are solid grouted cores, or partially grouted cores with the unfilled cells either empty or filled with any type of insulation.

4. **WALL R-VALUE ($R_w$)** - for hollow masonry, use Table B-4; for solid unit masonry or solid concrete walls, use Table B-5. Select the appropriate R-value and enter it here (see Section 3.1.2F for more discussion).

5. **WALL HEAT CAPACITY (HC)** - for hollow masonry, use Table B-4; for solid unit masonry or solid concrete walls, use Table B-5. Select the appropriate HC value and enter it here (see Section 3.1.2H for more discussion).

## *C. Furring/Insulation Layer*

This section is used to describe any furring/insulation layers or insulating sheathing attached to either the inside or the outside of the masonry.

1. **FURRING FRAMING MATERIAL** - list the type of material (wood, metal) used for the furring strips; if not applicable enter "none".

2. **FURRING FRAMING SIZE** - enter the thickness, width, and depth, in actual inches, of the framing members used for furring, and its actual dimensions in inches.

3. **FURRING SPACE INSULATION** - enter the type of insulation installed in the space between furring strips (fiberglass batt, bead board, etc.), and its R-value at the installed thickness.

4. **EXTERIOR INSULATING LAYER** - if there is an exterior insulating layer, list the type of insulation (bead board, polyisocyanurate board, etc.), and its R-value at the installed thickness.

5. **FURRING ASSEMBLY EFFECTIVE R-VALUE** - using the information above, enter Table B-6 and locate the effective R-value of the furring assembly (see Section 3.1.2F).

6. **INSULATION LAYER R-VALUE ($R_f$)** - add the FURRING ASSEMBLY EFFECTIVE R-VALUE to the R-value of the exterior insulating layer to arrive at the INSULATION LAYER R-VALUE ($R_f$).

## *D. Wall Assembly R-value and U-value*

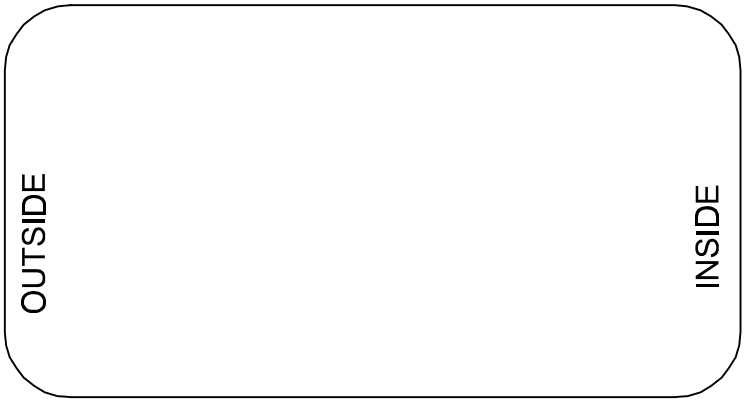
1. **WALL ASSEMBLY R-VALUE ($R_t$)** - add the INSULATION LAYER R-VALUE calculated above ($R_f$) to the WALL R-VALUE ($R_w$) from above to obtain the WALL ASSEMBLY R-VALUE.

2. **WALL ASSEMBLY U-VALUE** - calculate the inverse of the WALL ASSEMBLY R-VALUE ($1/R_t$) to obtain the WALL ASSEMBLY U-VALUE.

# PROPOSED MASONRY WALL ASSEMBLY ENV-3

| PROJECT NAME | DATE |
|---|---|
| | |

## COMPONENT DESCRIPTION




SKETCH OF ASSEMBLY

**ASSEMBLY NAME**

**DESCRIPTION OF ASSEMBLY**

## WALL R-VALUE and HEAT CAPACITY

| | | |
|---|---|---|
| **WALL UNIT THICKNESS** | | NOMINAL INCHES |
| **MATERIAL TYPE** | | (LW CMU,MW CMU, NW CMU, CLAY UNIT, CLAY BRICK, CONCRETE.) |
| **CORE TREATMENT** | | (SOLID, GROUTED, EMPTY, INSULATED, NA) |
| **WALL R-VALUE** | | Rw (FROM TABLE B-4 or B-5) |
| **WALL HEAT CAPACITY** | | HC (FROM TABLE B-4 or B-5) |

## FURRING/INSULATION LAYER (INSIDE and/or OUTSIDE IF ANY)

| | | | | |
|---|---|---|---|---|
| **FURRING FRAMING MATERIAL** | | (WOOD, METAL, NONE) | | |
| **FURRING FRAMING SIZE** | | NOMINAL INCHES | | ACTUAL INCHES |
| **FURRING SPACE INSULATION** | | TYPE | | R-VALUE |
| **EXTERIOR INSULATING AREA** | | TYPE | | R-VALUE |

| **FURRING ASSEMBLY EFFECTIVE R-VALUE** | | **EXTERIOR INSULATING LAYER R-VALUE** | | **INSULATION LAYER R-VALUE** |
|---|---|---|---|---|
| | + | | = | Rf |
| (FROM TABLE B-7) | | (FROM MANUFACTURER) | | |

## WALL ASSEMBLY R-VALUE and U-VALUE

| **INSULATION LAYER R-VALUE** | | **WALL R-VALUE** | | **WALL ASSEMBLY R-VALUE** | | **WALL ASSEMBLY U-VALUE** |
|---|---|---|---|---|---|---|
| | + | | = | | → | |
| **Rf** | | **Rw** | | **Rt** | | **1/Rt** |

# ENV-3: Proposed Wood Frame Assembly

This version of ENV-3 should be used for any construction assembly which is not found in the tables in Appendix B or appropriate for the metal framed or masonry versions of ENV-3. This form guides the user through the basic U-value calculation, the Parallel Path Method (discussed in Section 3.1.2D), and the heat capacity calculation (see Section 3.1.2H). If the proposed wood-framed floor or ceiling assembly is one of the Standard Framed Floor/Ceiling Assembly types shown in Table B-3 of Appendix B, it is not necessary to submit Form ENV-3 "Proposed Construction Assembly". Instead, the "Reference Name" for the appropriate assembly is entered into either Form ENV-2 "Envelope Component Method" or ENV-2 Part 2 "Overall Envelope Method", whichever is applicable for the compliance method that the designer has selected. Refer to the specific sections in the Manual which provide instructions for filling out the respective forms, as to how the Reference Name of the assembly should be entered.

1. **PROJECT NAME** is the title of the project, as shown on the plans, on the ENV-1, and as known to the building department.

2. **DATE** is the date of preparation of the compliance submittal package. It should be on or after the date of the plans, and on or before the date of the building permit application.

## *A. Component Description*

1. **SKETCH OF ASSEMBLY** - provide a simple cross-section sketch showing the arrangement of components in the assembly. The position of framing members and layers should be apparent. Number the layers in sequence from outside to inside as they will be described below (framing members are not numbered, only the cavity layers are considered here). Note the outside of the assembly, facing unconditioned space, is at the left of the sketch.

2. **ASSEMBLY NAME** - list the name or designator for this assembly as it is referred to on the plans and on the other compliance forms in the submittal, e.g. WALL-1, ROOF-2, or some other naming convention appropriate to the construction document organization.

3. **ASSEMBLY TYPE** - check the appropriate box.

4. **FRAMING MATERIAL** - with this form framing material is wood only (other versions of ENV-3 are for other materials).

5. **FRAMING SIZE** - enter the nominal dimensions of the framing members, e.g. 2x4, 4x8, or other appropriate description.

6. **FRAMING PERCENTAGE** - choose the appropriate value from the small table to the right. For example, a floor assembly with joists spaced 24" on center (o.c.) would have a framing percentage of 7%.

## *B. Construction Components*

In this part of the form, the R-value of the cavity (the area of the assembly that does not contain framing members) and the R-value of the assembly through the wood framing are calculated. The U-value of the assembly is also calculated.

1. **DESCRIPTION** - list each layer of the assembly in sequence, from outside to inside, as numbered in the sketch above.

2. **CAVITY R-VALUE ($R_c$) -** enter the R-value of each layer at a cross-section taken through the cavity. This value is taken from manufacturer's literature or from *the ASHRAE Handbook of Fundamentals Volume, 1993,*

(Chapter 22, Table 4, *Typical Thermal Properties of Common Building and Insulating Materials*) data reproduced in Appendix B, Table B-1. The R-values for the INSIDE and OUTSIDE SURFACE AIR FILMS are taken from Table 3-1, Standard Air Film R-values.

3. **WOOD FRAME R-VALUE ($R_f$)** - enter the R-value of each layer at a cross-section taken through a framing member. These values are found in the same sources cited in the previous paragraph.

**HEAT CAPACITY (HC) -** As an option, the HC of the assembly may also be calculated, although for most framed assemblies the HC will be too low to be of significance (HC values of less than 7 are not given any special consideration under the *Standards*).

4. **WALL WEIGHT -** enter the weight of each layer of the assembly, per square foot of the material at its given thickness. This is calculated from the density of the material, which is given in pounds per cubic foot. See Table 3-11 for typical values; they may also be taken from manufacturers literature or other standard reference works, such as the *ASHRAE Handbook of Fundamentals Volume, 1993*, Chapter 22 Table 4 (Appendix B). Dividing the density by 12 and multiplying by the material thickness (in inches) yields the WALL WEIGHT. For the framing material, the weight of the framing members must be converted to a pounds per square foot value.

5. **SPECIFIC HEAT** - enter the specific heat of each material, in Btu/°F-lb. These values are also found in ASHRAE Table 4 (see previous paragraph).

6. **HC** - columns A and B are multiplied together to obtain the heat capacity for each layer of the assembly.

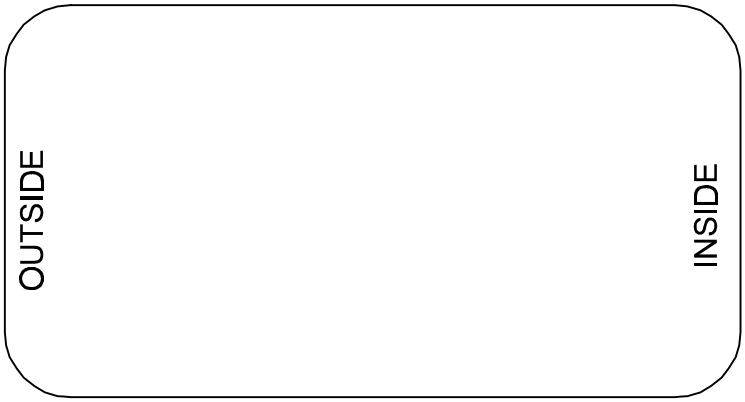
   **SUBTOTALS** - both R-value columns are summed. If calculated, the HC column is also summed to obtain the TOTAL HC for the assembly.

**ASSEMBLY U-VALUE** - the appropriate values from above on this form are entered into the equation and the result calculated. Rc is the subtotal of the CAVITY R-VALUE column; $R_f$ is the subtotal of the WOOD FRAME R-VALUE column. Fr% is the FRAMING PERCENTAGE. Care should be taken to recognize the parentheses in the calculation.

# PROPOSED WOOD FRAME ASSEMBLY ENV-3

| PROJECT NAME | DATE |
|---|---|
| | |

## COMPONENT DESCRIPTION




SKETCH OF ASSEMBLY

**ASSEMBLY NAME** _____

**ASSEMBLY TYPE** (check one)
- ☐ **Floor**
- ☐ **Wall**
- ☐ **Ceiling/Roof**

**FRAMING MATERIAL** ☐

**FRAMING SIZE** ☐ Fr %: _____

**FRAMING PERCENTAGE** ☐
15% (16" o. c. Wall
12% (24" o. c. Wall)
10% (16" o. c. Floor/Ceil.)
7% (24" o. c. Floor/Ceil.)

## CONSTRUCTION COMPONENTS

| | | R-VALUE | | HEAT CAPACITY (optional) | | |
|---|---|---|---|---|---|---|
| | | A | | B | | |
| | DESCRIPTION | CAVITY R-VALUE (Rc) | WOOD FRAME R-VALUE | WALL WEIGHT lbs/sf | SPECIFIC HEAT (Btu/F°•lbs) | HC (A×B) (Btu/F°•sf) |
| | **OUTSIDE SURFACE AIR FILM** | | | | | |
| **1** | | | | | | |
| **2** | | | | | | |
| **3** | | | | | | |
| **4** | | | | | | |
| **5** | | | | | | |
| **6** | | | | | | |
| **7** | | | | | | |
| | **INSIDE SURFACE AIR FILM** | | | | | |
| | **SUBTOTAL** | | | | **TOTAL HC** | |
| | | Rc | Rf | | | |

[ ☐ **1/Rc** ] x [ ☐ **1 - (Fr%/100)** ] + [ ☐ **1/Rf** ] x [ ☐ **Fr%/100** ] = ☐ **ASSEMBLY U-VALUE**

## COMMENTS